

## Chapter 17 Piping

### 17-1. General

The provisions of this chapter are applicable to all equipment and systems covered in this manual, wherever piping is required.

### 17-2. Design Considerations

The design considerations noted in the following paragraphs are those more frequently encountered in the design of powerhouse systems but are not intended as a complete listing. Other factors pertinent to the cost, life, and utility of piping in each particular powerhouse should also receive proper consideration in the design and design analysis. Caution and judgment are essential in applying factors and criteria available to ensure a satisfactory and economical design. The extent and degree of precision in design analysis should be consistent with the assumptions and other information available. For example, quantities or flow rates are often necessarily based on rather rough assumptions, and where this is true, a brief and approximate analysis with conservative pipe sizing should be the rule. Complex and extensive systems with well-verified assumptions warrant more detailed and exact analysis to match pipe sizes as near as possible to requirements.

*a. Pipe sizing.* The following factors should be considered in determining suitable pipe sizes. Most of these are interactive in their effect on pipe size, and care in selecting the critical factor is essential.

(1) Velocity. Velocity in itself will occasionally become a limiting factor in piping design, but this is usually only when erosion or cavitation would cause premature failure, noise could be a problem, or, in the case of pipe used to transport fish or other materials, velocities are determined by other than piping considerations. Even when these limiting factors appear to apply, full consideration should be given to whether the limiting velocity is normal, infrequent, or temporary. An infrequent or temporary eroding velocity may well be justified in the interest of overall economy. For waterlines, velocities in the range of 2.4-3.7 m/s (8-12 fps) are usually considered reasonable, but there is often good justification for higher or lower velocities. Copper waterline velocities should not exceed 2.1 m/s (7 fps) continuously.

(2) Pressure loss. Pressure loss is often a limiting factor on pipe sizing when a fixed gravity head is

available or where the pipe is a minor part of a pumped system with the pump head determined by other major requirements.

(3) Pumping cost. Pumping cost can be a significant factor in sizing pipe and requires careful analysis for extensive systems with high use factors, both in regard to energy cost and connected electrical load.

(4) Corrosion allowance. Allowance for restriction and increased pressure loss due to corrosion or mineral deposits is necessary, depending largely on pipe material and water chemistry. For steel pipe under average water conditions, a reduction in cross-sectional area of 15 percent is a suitable corrosion allowance. Average pressure loss computations should be based on moderately corroded pipe.

(5) Code requirements. Minimum pipe sizes specified by NAPHCC 1265, "National Standard Plumbing Code" or applicable state code should be complied with.

(6) Previous projects. Previous installations of similar systems can be a valuable guide in selecting pipe sizes, particularly when complete design analysis along with good service records are available.

(7) Other factors.

(a) Equipment connection sizes. These sizes are generally significant only for short runs of connecting piping.

(b) Mechanical strength. When the pipe is small, consider where shock conditions could disturb pipe alignment. It can be more satisfactory to use a larger size pipe than to provide the additional supports for a very small pipe.

(c) Temperature. The use of copper and galvanized steel for hot water in the 60-77°C (140-170°F) range on a continuous basis should be avoided.

(8) Precautions.

(a) Equipment demand forecasts. Where sizing is based on advance equipment demand estimates, the analysis should so note, and office procedures should provide for rechecking analysis against contract figures.

(b) Coordination. Much of the information on which pipe sizing is based comes from equipment supplier representatives, other engineering disciplines, and operation

sources. Many costly design changes, change orders, and poor operating conditions have resulted from this exchange of information. It is the design engineers responsibility to ask the right questions, make sure the listener understands the purpose of the question, and verify, reverify, and coordinate answers from all available sources.

(c) Plant expansion. Allowance in pipe sizing for possible plant expansion is often warranted, particularly in embedded piping.

(d) Corrosion. See Chapter 19 for additional considerations on corrosion control.

*b. Materials.* A material schedule with recommended materials for all standard powerhouse applications is included in Figure B-13. Except as noted in the piping schedule, whenever possible nonmetallic pipe should be used when buried outside of the powerhouse.

(1) Applying material schedule. To apply the material schedule, pipe wall thickness, fitting ratings, and valve ratings should be verified for each application. Particular attention is due unusual pressure or shock possibilities which could occur from misoperation, high pool or tailwaters, or equipment changes. The existence of unusual corrosive characteristics of the fluid being handled should be investigated, and material adjustments justified accordingly.

(2) Deviations. In evaluating a proposed deviation the following factors should be considered:

- (a) Procurement cost.
- (b) Installation cost.
- (c) Life.
- (d) Normal availability.
- (e) Replacement cost.
- (f) Maintenance.
- (g) Appearance.
- (h) Reliability.

Design memoranda should include justification for deviations, and advance consultation with review offices is warranted, particularly in the case of new products.

(3) New products, testing, or experience record. Lack of a comprehensive experience record could justify a limited trial in a noncritical application if significant improvements are otherwise indicated.

*c. Routing.*

(1) Embedded versus exposed. Embedded piping has several inherent problems and should be avoided whenever practicable (see Figure B-19). Some problems with embedded piping are as follows: proper placement during construction is difficult to enforce; damage from aggregate may go undetected; filling with concrete occasionally occurs; it is difficult to obtain the necessary flexibility in crossing contraction joints; and corrosion, particularly near the point of emergence from concrete, is impossible to completely monitor or control. For these reasons, exposed piping is generally preferred. Usually drainage and vent lines are not practicable to run exposed.

(2) Routing considerations. The bulk of exposed piping is generally placed in galleries, vertical pipe chases, and covered pipe trenches. Obtaining adequate space in these areas is often difficult and requires early planning to avoid later compromises in good operation and maintenance. As soon as Preliminary Design Report has been approved, preliminary layouts showing tentative equipment locations and preferred routing of all interconnecting piping should be developed as a basis for requesting the necessary structural and architectural provisions. The most effective approach to this layout is to refer to drawings of other recent, similar powerhouses and when possible obtain comments from operating and maintenance personnel on the pipe locations in these powerhouses. Design offices without file copies of recent powerhouses should obtain drawings from other offices and consult with experienced piping layout personnel in other offices. The following factors enter in to optimum routing and should receive continued consideration during the design process:

- (a) Dismantling and assembly.
- (b) Valve maintenance and replacement.
- (c) Supports.
- (d) Draining.
- (e) Provisions of sleeves and blockouts through concrete walls, floors, and columns.
- (f) Length of lines.

(g) Insulation.

(h) Expansion.

(i) Sound.

(j) Line failure.

(k) Corrosion.

(l) Leakage.

(m) Condensation.

(n) Appearance.

(o) Coordination with electrical and structural requirements.

Blockouts are usually preferred over sleeves since they permit more flexibility in modifying the piping arrangement during design and construction and expedite installation.

*d. Supports and anchors.*

(1) General. Supports and anchors may be separate units or may be combined in single units. Loadings are normally quite readily determined, and commercial units with established load ratings should be used for most applications.

(2) Design practice.

(a) In horizontal lines, normally locate anchors approximately midway between expansion joints or loops. In longitudinal galleries, this usually results in anchors located near the center of each bay and expansion joints or loops at the building contraction joints. However, it is often expedient and satisfactory to provide the required expansion joints or loops at other locations more convenient for assembly and disassembly.

(b) In vertical lines, locate anchors at upper ends when practical to minimize the required number of guides.

(c) A guide spool should be located close to and on each side of expansion joints and loops.

(d) Multiple-type supports should provide space for servicing individual lines.

(3) Precautions.

(a) Where several pipes are to be mounted on one series of supports, spacing and load ratings should be as determined for the critical line.

(b) Supports at branches should be considered for required expansion in both lines.

(c) Friction in sleeve-type expansion joints should be considered in anchor design.

(d) Consider all possibilities for longitudinal forces because of valve operation at changes in direction, including safety and relief valves.

(e) Include both pipe movement and structural displacement as contraction joints.

(f) All guide-type supports should provide free longitudinal movement of lines. On the U-bolt type, two nuts, one on each face of the supporting member to ensure a proper clearance, are required.

(g) Lock washers or double nuts should be used on all supports to avoid loosening from normal powerhouse vibration.

(h) Anchor design should provide for forces imposed during testing and any unusual temperature conditions during construction.

(i) Supports for copper lines should be copper plated, or the dissimilar metals isolated by a nonconducting medium such as electrical insulating tape.

*e. Pipe joints.*

(1) General. The preferred types of joints for each piping system are listed in the "pipe" column of the piping material schedule, Figure B-13.

(2) Location. Most joint locations will be determined by available pipe lengths, the requirements for fittings, valves and connected equipment, fabrication process, and installation requirements. In addition, the following should be provided:

(a) Union or flanged joints in all steel lines should be downstream from valves.

(b) Exposed sleeve-type joints are adjacent to the point at which embedded piping is continued with exposed piping.

(c) Sleeve-type joints should generally be provided where piping connects with pumps or other equipment, unless the piping involved is small and obviously flexible enough to eliminate concern for vibration effects and strain due to misalignment. Vibration and strain effects should be considered both on piping and the connection equipment.

(d) Two sleeve-type couplings should be provided where embedded piping passes through valve pits (one on each additional line that may enter the valve pit).

(e) Sleeve, U-Bends, or bellows-type flexible joints should be provided in exposed piping at, or near, contraction joints.

(f) Insulating (dielectric) connections should be provided between lines involving dissimilar metals and between ferrous pipe lines exposed in the powerhouse which continues buried in soil outside. Fittings should be located immediately inside of the powerhouse wall, and precautions should be taken to assure that the pipes are isolated from the copper ground mat.

(3) Expansion joints.

(a) Flexible element. A number of flexible element-type joints are available as catalog items. These joints have the capability for good service under severe conditions within their capabilities. Their principal advantages over sleeve-type couplings are freedom from leakage as long as they remain intact, lesser frictional forces, and the ability to accept greater misalignment, except torsional. Their disadvantages are the necessity for immediate replacement in case of failure and a lack of a recognized specification standard. Where predictably ideal design conditions can be obtained and maintained, their use can be justified.

(b) Sleeve-type joints. Sleeve-type joints are well suited for expansion and contraction, as well as torsional displacement, but are not suitable for radial misalignment and will accommodate angular misalignment to only a very limited degree before axial displacement forces become unpredictable. All sizes are commercially available and should be applied in accordance with their limitations. Two joints in close proximity on the same line can be used to provide for some radial displacement.

(c) U-Bends. U-Bends are an excellent type of joint for all movements in piping and are trouble free when properly designed and installed. Space considerations are often a problem in powerhouse application of U-Bends, and their cost is usually higher than other types of flexible joints. Their use has generally been confined to long, high-pressure, hydraulic oil headers in galleries. Commercially available U-Bends are available and should be specified in accordance with their catalog ratings.

*f. Valving.*

(1) General. Valves regularly used in powerhouse piping include gate, globe, plug, ball, butterfly, check, pressure reducing, and relief valves. Valves should be provided as required for control (open-closed-modulating); isolating; bypassing; prevention of backflow; protection against overpressure; and in many cases, where not an actual requirement, for convenience of operation and maintenance. They should be located, whenever practicable, for convenient access. If convenient access is not practicable, they should generally be provided with remote control unless their only use would be a very infrequent noncritical maintenance operation. For maintenance purposes, design consideration should be given to minimizing the number of types of valves in a particular powerhouse. Backseating valves or other types permitting repacking under pressure should generally be provided.

(2) Valve selection.

(a) Gate valves. Rising stem, single-wedge gate valves fulfill the bulk of the requirements for nonmodulating control valves. Nonrising stem gate valves with indicators can be used in special applications where space does not permit a rising stem. However, the operating disadvantage of having the screw threads in the contents of the pipe should be considered.

(b) Globe valves (including angle valves). For modulating requirements and some critical drop-tight shutoff requirements, globe valves should normally be used.

(c) Plug valves. Plug valves may be used for applications where operation would be infrequent, a relatively fixed modulation is required, or in some cases, where quick operation is a requirement. They have the disadvantages of a tendency to get frozen in a particular setting, developing small seepage leaks, and requiring lubrication in some applications, so careful consideration is necessary as to the actual overall benefits of their use.

(d) Ball valves. Full-ported, nonmetallic, seated ball valves are becoming increasingly available at competitive prices and offer tight shutoff, quick operation, and relatively easy maintenance. Their use can be justified for many applications and locations, especially in smaller sizes, 80 mm (3 in.) and less.

(e) Butterfly valves. Butterfly valves of the rubber-seated type offer significant cost advantages for some low-pressure larger size applications. In some cases, their relatively low operating forces permit elimination of powered operators. Butterfly valves may be used to modulate flow under certain circumstances but only through disc opening angles of 45 to 90 deg. Their relatively inexpensive production plant requirements have made them a popular production item with many manufacturers of limited experience. Particular care in obtaining a reputable product in accordance with the material schedule is necessary.

(f) Check valves. Conventional ball check, lift check, and swing check valves are all used regularly in powerhouse piping. Applications involving frequent flow reversals should generally be of the nonslam type. Some applications requiring low-pressure loss and minimum shock can justify selection of one of several patented "silent" check valves.

(g) Pressure-reducing and relief valves. When pressure-reducing valves are required to maintain a lower pressure system supplied by a higher pressure source, the lower pressure side should be further protected by one or more relief valves. A slightly undersized relief valve is preferable to an oversized valve to minimize erosion due to near shutoff operation. A manual bypass around the pressure-reducing valve is permissible; however, the maximum flow capacity of the bypass should be less than the relief capacity of the low-pressure system. A pressure gauge should be provided on the low-pressure system. The designer should be aware that pressure-reducing valves, as well as relief valves, are subject to wear and malfunctions, and great care is essential in their application, particularly in systems with maximum to zero flow requirements. Where the pressure differential is sufficient to jeopardize plant operation or safety, a positive stand-pipe overflow relief system or an alternate low-pressure source would be preferable.

*g. Miscellaneous.*

(1) Cleaning. In Appendix B specification, "Piping-Cleaning and Flushing," the cleaning and flushing procedure of piping is covered (see paragraph B-2). Similar

provisions should be included in all powerhouse contract specifications. The piping designer should be aware of the cleaning provisions and layout of the piping, particularly the embedded portion, to permit the best access possible. Wherever practicable, provide straight runs without bends or offsets between access points.

(2) Testing. As a general rule, all pressure piping should be tested to 1.5 times the maximum working pressure (embedded piping prior to embedment) with a minimum of 689 kPa (100 psi). Drainage waste and vent piping should be tested to a minimum 3-m (10-ft) head. The designer should consider the testing during design and include any required special provisions to protect specialized components of systems against the test pressure. Code test provisions are included in NAPHCC 1265 and ASME A 31.1. A typical test paragraph, "Pressure Tests," is included in Appendix B specification, "Powerhouse Piping," (see paragraph B-3).

(3) Insulation. Insulation should be provided to prevent condensation on water and drain pipe passing over electrical equipment or over suspended ceilings and on exposed interior roof drains. The requirement for insulation on water or drain piping to prevent freezing should also be investigated. Wherever practicable, freeze protection should be accomplished by protected routing of the lines or by planned draining of the lines in cold weather. Where this is not practicable, insulation (plus heating if necessary) should be provided. To evaluate the need for heating, all potential extended time no-flow conditions should be considered. Figure B-20 (sheets 1-6) shows a typical pipe insulation specification provision. Also refer to Guide Specification CE-15250.

(4) Painting. Painting of piping is covered in EM 1110-2-3400 and Guide Specification CW-09940. However, the cost of painting and maintenance is affected by pipe material routing and mounting and should be considered during design. Nonferrous piping is normally left unpainted. The cost of painting and maintenance should also be considered in the selection of galvanized or black piping since painting of galvanized piping in non-painted areas is normally not required. In areas where condensation is likely to be continuous on cold water lines, galvanized piping and supports may need to be supplemented with coatings or pipe insulation.

(5) Identification. A pipe and valve identification system is required for each project. Specification provisions for a typical powerhouse are included in Appendix B, paragraph B-4, "Piping System Identification."

(6) Hydraulic piping. Piping for high-pressure hydraulic-operating systems is a specialty-type piping and is covered separately along with the hydraulic equipment as a complete system.

*h. Design analysis.* A design analysis should be prepared for each piping system. Included should be

criteria, system assumptions, flow requirements, velocities, heads, losses, pipe sizing and materials, pump requirements, routing considerations, expansion and contraction of piping and structure, expansion joint requirements, support and anchor loadings and selections, and other factors considered during system design.